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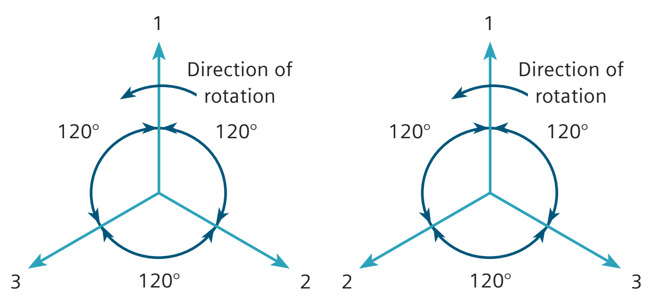
Phase sequence versus phase arrangement

Two of the fundamental issues in electric power that are often confused are the concepts of:

- Phase sequence, and
- Phase arrangement.

Phase sequence

Phase sequence refers to the relation between voltages (or currents, as well) in a three-phase system. The common representation of this relation is in terms of a phasor diagram, as below:

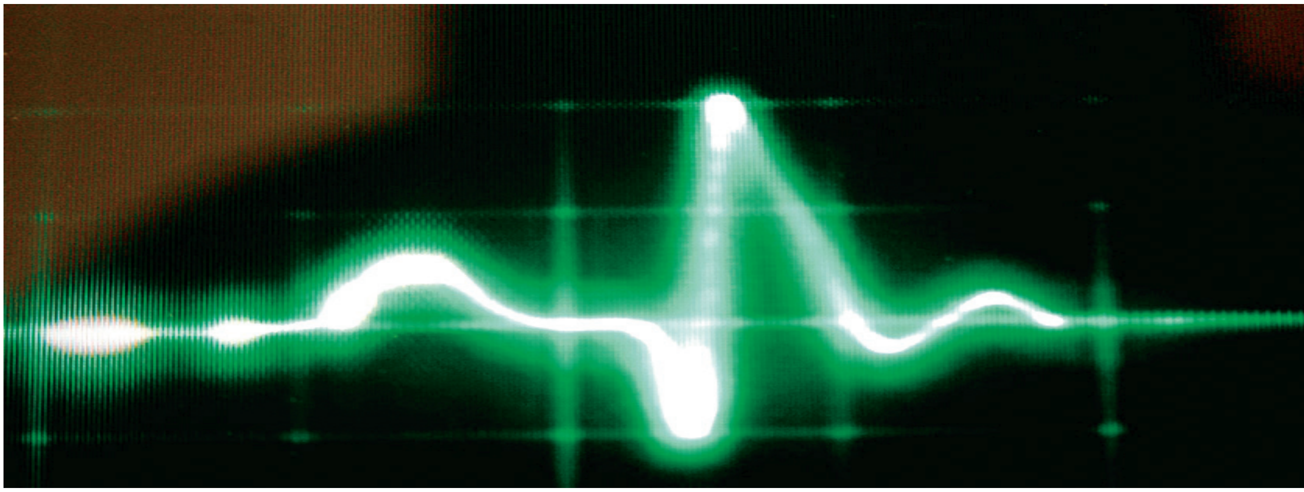


1-2-3 phase sequence   3-2-1 phase sequence

The phasor diagram represents the phasor (or vector) relation of the three phase-ground voltages (for simplicity, in a balanced system). The diagram is based on counter-clockwise rotation, and in a system with 1-2-3 phase sequence, the voltage with respect to time in phase 1 reaches a peak, followed 120 electrical degrees later by phase 2, and similarly, phase 2 is followed 120 electrical degrees later by phase 3.

The phase sequence in a power system may be the normal 1-2-3 phase sequence, or may be reversed, 3-2-1. The diagram shows both the normal 1-2-3 as well as the reversed 3-2-1 phase sequence. While the common language of switchgear suppliers uses the 1-2-3 nomenclature, some purchasers use other designations, such as A-B-C, R-Y-B, R-S-T, etc. Regardless of nomenclature, the concept is the same.

Phase sequence is critical in measurements on power systems, and for protective relaying, but perhaps most importantly, for rotating machines (so machines do not run backwards). Modern microprocessor protective relays have a selectable phase-sequence setting (often called the phase-rotation setting), so the relay adapts to the phase sequence without ordinarily requiring changes to the wiring connections. In the historic electromechanical relays (and meters), the wiring connections had to reflect the phase sequence to enable accurate measurements and protection.



Phase arrangement

Switchgear is constructed with consistent phase relationships, so that when correctly installed, the user and maintenance personnel know how the phases are arranged. The standards specify the required phase arrangement in a consistent manner. IEEE C37.20.1 (for low-voltage metal-enclosed switchgear), IEEE C37.20.2 (for medium-voltage metal-clad switchgear) and IEEE C37.20.3 (for medium-voltage metal-enclosed interrupter switchgear) all require that the phase conductors be arranged 1-2-3 from front to rear, top to bottom, or left to right, when viewed from the front of the switchgear. Other types of equipment, including low-voltage switchboards (UL 891) and low-voltage motor control centers (UL 845) also specify this arrangement.

It is important to understand that the phase arrangement (the physical configuration of the bus bars and connections in switchgear) almost never changes. Equipment is almost universally designed for 1-2-3 phase arrangement from top to bottom, left to right, and front to rear, when viewed from the front of the switchgear. Standards require that when it is necessary to modify this arrangement, the phasing be marked conspicuously.

However, the electrical phase sequence of the equipment can be specified by the purchaser of the equipment. Usually, this involves no change to the switchgear, as the phase sequence is usually selectable with modern microprocessor instrumentation and protective devices. If historic electromechanical meters or relays are used, the manufacturer will need to connect the wiring for these devices to reflect the electrical phase sequence specified by the purchaser.

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